1.0 *INTRODUCTION*

On behalf of Pan Am Railways (Pan Am, formerly Boston & Maine Railroad), ERM Consulting and Engineering, Inc. (ERM) has prepared this Completion Report for the Iron Horse Park Superfund Site (the "Site"), Operable Unit 3 (OU3), Area of Concern (AOC) 3 in Billerica, Massachusetts. Activities were conducted in accordance with the United States Environmental Protection Agency (USEPA) Record of Decision (ROD) for OU3 dated 30 September 2004 and followed the requirements detailed in the Remedial Design (RD)/Remedial Action (RA) Statement of Work (SOW) for OU3. ERM was retained by Pan Am Railways to be the Engineer of Record for the RD/RA.

This Final Remedial Construction Report and the accompanying set of As-Built Drawings (Appendix A) summarize and document the activities performed leading to the completion of the ROD field activities at the Site. All activities were completed in accordance with the following reports associated with AOC 3 unless otherwise noted:

- *Final Design Report for AOCs 1, 2, and 3* dated 24 September 2012; and

- *Remedial Action Work Plan for AOC 3* dated 25 July 2018.

This report presents the RA activities associated with AOC 3 as completed between 10 September 2018 and 6 August 2019. This report and accompanying drawings discusses the remedial activities, "As-Built conditions," site quality assurance / quality control (QA/QC), design modifications, and achievement of Applicable or Relevant and Appropriate Requirements (ARARs).

The following major sections are included in this Completion Report:

- 1.0 Introduction;
- 2.0 Remedial Action Requirements;
- 3.0 Construction Implementation;
- 4.0 Construction Modifications;
- 5.0 Construction Quality Assurance/Quality Control;
- 6.0 Institutional Controls;
- 7.0 Regulatory Compliance Assessment; and
- 8.0 Future Requirements.

Each section discusses specific Site issues leading to the completion of the RA. Data collected throughout the RA process is appended for reference as supporting documentation.

1.1 BACKGROUND

The Site is located in Billerica, Massachusetts, near the Tewksbury town line, approximately 20 miles northwest of Boston (Figure 1). The Site is a 445-acre industrial complex, which includes manufacturing and railyard maintenance facilities, open storage areas, landfills, and former wastewater lagoons. The Site is used for industrial purposes, with no residential use. The majority of the Site has been disturbed by man-made activities associated with industrial use for almost 100 years. Structures, access roads, storage areas, and landfills cover the majority of the Site.

Ground elevation is generally flat with gradual slopes associated with each of the landfill or disposal areas. The Site is surrounded by upland areas on the southeast side, including several small forested hills near Pond Street, and low-lying wetland areas on the western, northern, and eastern side of the Site. Approximately 17 percent of the Site is covered by wetlands.

The area surrounding the Site is a mix of residential, industrial, and undeveloped land. It is bounded to the north by the B&M railroad tracks, to the west by High Street, to the east by Gray Street, and to the south by a wetland, Pond Street, and the Middlesex Canal.

The B&M Locomotive Shop Disposal Areas (AOCs 3A and 3B) are divided by a man-made channel that flows into perennial Stream A. AOCs 3A and 3B are located north and south of the channel, respectively. AOCs 3A and 3B are 0.4 and 3.6 acres, respectively. Organic compounds, including PAHs, petroleum hydrocarbons, pesticides, and metals were detected in surface and subsurface soils of the AOC 3 units. The highest concentrations of PAHs were generally detected in subsurface soils.

The risk assessment conducted for AOC 3 as presented in the Remedial Investigation (RI) Report dated September 1997 concluded that:

- Soils pose a potential risk to human health based on measured lead concentrations; and

- Soils pose a potential risk to environmental receptors based on measured copper and lead concentrations.

Based on this information, AOC 3 required the implementation of remedial action measures that will (ROD 2004):

- Protect human receptors from exposure to lead in soil;
- Protect environmental receptors from exposure to copper and lead in soil; and
- Limit the migration of contaminants in soil to groundwater.

1.2 PROJECT ORGANIZATION

The RA implementation was conducted by management, inspection, and construction personnel organized to effectively administer, supervise, inspect, and construct the prescribed RA in a sound engineering manner and in compliance with the approved RD, ROD and Consent Decree. Pan Am retained ERM as the engineer of record for the RD/RA SOW, to oversee the construction subcontractor, as needed, and be the Construction Quality Control Officer to ensure compliance with the prescribed requirements. The responsibilities assigned to individual project participants are discussed in this section.

1.2.1 Construction Subcontractor

ERM retained Charter Contracting Company, LLC. (Charter) as the subcontractor for the implementation of the RA. Charter was responsible for furnishing the labor, methods, services, materials, equipment, and installation of all materials related to the RA prescribed in the ROD. Charter was also responsible for implementing construction quality control (CQC) activities for the project. Charter was represented by of the following personnel:

- Charter Project Manager: Chris Ryan
- Charter Field Superintendent: Jeff Hebb
- General Contractor: Charter Contracting Company, LLC

Additionally, Charter retained the following specialty subcontractors during the project:

- Land Surveyor: Dana F Perkins, Inc.
- Brush Clearing: Northern Tree Service, Inc.

- Erosion Control Installation: S&M Farms, Inc.
- Sheet Pile Supplier: Skyline Steel, Inc.
- Sheet Pile Installation: Sea and Shore Contracting, Inc.
- Water Treatment System Installation: Lockwood Remediation Technologies, LLC
- Third Party Wetland Specialist: SWCA Environmental Consultants
- Geosynthetic Manufacturer: Solmax-GSE
- Geosynthetic Installation: Chenango Contracting, Inc.
- Materials Testing: GeoTesting Express, Inc.
- Structural Fill/Cover Soil Supplier: Newport Aggregates
- Wetland Organic Fill Supplier: BMC Corp.
  Aggresource, Inc.
- Topsoil Supplier: Newport Aggregates
  BMC Corp.
- Wetland Hydroseeding: Hydrograss Technologies
- Straw and Tackifier Application, Cap Hydroseeding: A.J. Cameron Sod Farms, Inc.
- Fence Supplier: Reliable Fence Boston

The following subcontractors were also retained by ERM to conduct additional activities at AOC 3:

- Utility Clearance: Ground Penetrating Radar Services, Inc.

1.2.2 *Construction Management*

ERM provided daily on-Site oversight to ensure design compliance and overall conformance with the RA and Contract Documents, which includes construction drawings and technical specifications. ERM's project personnel interacted regularly concerning site coordination and construction matters and a weekly progress meeting was conducted to summarize completed and upcoming activities at the Site. The construction management team was comprised of the following personnel:

- Engineer of Record & Project Manager: Stacey B. Harvey, P.E., ERM
- Partner in Charger: Lyndsey Colburn, P.G., ERM
- Senior Engineer: Darren Quillen, P.E., ERM
- Construction Manager: Mark Jurgensen, ERM
- CQA Manager: Michael Pettit, E.I.T., ERM
- Field Safety Officer & CQA Inspector: Alec Randall, E.I.T., ERM

1.2.3 Regulatory Agency Inspections

The USEPA and Massachusetts Department of Environmental Protection (MassDEP) were responsible for oversight of remedial activities. The USEPA and MassDEP had the authority to inspect the construction site, review the design and any field revisions, verify that the CQA/CQC practices were being appropriately implemented, and verify that the construction was in compliance with the approved RA.

Don McElroy, USEPA, and Janet Waldron, MassDEP, conducted inspections as part of their periodic attendance at weekly progress meetings held on-site every Wednesday for the duration of the project. Additionally, a representative of AECOM (under contract to USEPA) conducted routine Site inspections approximately 2 to 5 times per week. A Pre-Certification Construction inspection was conducted on 6 August 2019. No follow up items were identified during this inspection besides regular operation and maintenance activities (e.g., wetland inspections, mowing, etc.).

2.0 REMEDIAL ACTION REQUIREMENTS

The RA implementation at the Site was conducted under the jurisdiction of the USEPA, and in accordance with the approved Revised Final Design for AOC 3 (Final Design), dated 24 September 2012.The Final Design was developed in response to the requirements in the RD/RA SOW.

2.1 AOC 3 REQUIREMENTS

In accordance with the 2004 ROD, remedial action measures for AOC 3 were required to limit the migration of contaminants in soil to groundwater. To ensure the RA accomplished the aforementioned goal, the RA measures included within the Final Design for AOC 3 consisted of the following:

- *Capping landfill material* – Grade slopes, install a single-barrier (Solid Waste cap), and install stormwater drainage structures (swales, rip-rap, perimeter drains), detention basins, and gas vents, as necessary;

- *Erecting a fence around the landfill* – Install fence to prevent unauthorized access in order to safeguard the public, and prevent damage to landfill structures;

- *Instituting land use restrictions* – Restrict activities (such as excavation and construction) which may damage the landfill cap and cause exposure to and migration of landfill contaminants;

- *Restoring wetlands impacted by the cleanup*- Install wetland soils and replant with appropriate species as necessary;

- *Inspecting and maintaining the landfill cap and fence on a periodic basis to ensure that it remains effective, inspecting and monitoring institutional controls and inspecting and maintaining wetland areas* – Define a maintenance program to inspect landfill structures, fence, and institutional controls and restored wetland areas and maintain/repair as necessary; and

- *Sampling groundwater periodically to assess the effects of the source control action (capping) and any ongoing impacts from the landfill, installing, if necessary, new monitoring wells*– Monitor groundwater quality downgradient of landfill.

The remedial action requirements were met and are documented in the activity descriptions and appendices presented herein (with the exception of instituting land use restrictions).

3.0 *CONSTRUCTION IMPLEMENTATION*

Charter was retained by ERM to provide all labor, equipment, and requisite materials to complete the construction and implementation of the RA. Their selection was the result of a competitive bidding process. Charter hired additional specialty subcontractors to perform minor supplemental tasks. During implementation, ERM provided construction and field-engineering oversight of the project.

3.1 *CONSTRUCTION OVERVIEW*

Charter mobilized to the Site on 10 September 2018 and began construction activities in accordance with the Contract Documents and the approved Final RD. The RA was substantially completed on 21 June 2019. ERM oversaw all portions of the construction activities and was on-Site during all construction activities. The Pre-Certification Construction Inspection was performed by representatives from ERM, USEPA, MassDEP, and AECOM on 6 August 2019 for AOC 3.

The work for AOC 3 consisted of the following:

- Installation of erosion and sediment controls.
- Removal of surface features including:
    - Trees/brush/stumps;
    - Concrete blocks;
    - Miscellaneous debris (spools, tires, railroad ties, etc.); and
    - Abandonment of four existing groundwater piezometers.
- Excavation of waste outside of the limits of cap and consolidation within the limits of cap.
- Landfill capping
    - Shaping, grading, and preparation of existing subgrade.

- Placement of cover materials including:
    - 60-mil textured low density polyethylene (LLDPE) geomembrane;
    - Geocomposite for lateral drainage – manufactured ~~of~~ two strands of parallel extruded high density polyethylene (HDPE) polymer strands, heat bonded at the intersection with non-woven geotextile thermally bonded to both sides;
    - 5,400 CY of cover soil; and
    - 2,900 CY of topsoil.
- Construction of access roads to the top of each landfill lobe.

- Wetland creation and restoration
  - Creating 31,318 square feet of new wetland;
  - Restoration of 10,246 square feet of existing wetland; and
  - 1,414 CY of organic fill.
- Final site restoration including seeding application and wetland planting, installation of site perimeter fencing, removal of erosion and sediment controls upon establishment of permanent vegetation.

With the exception of those activities presented in Section 4.0 – Construction Modifications, these construction events were conducted in accordance with the construction drawings, technical specifications, and the final RD.

3.2 CONSTRUCTION SEQUENCE

RA implementation was planned and conducted in a logical series of activities to facilitate the execution through substantial completion. The total duration of this project was ten months.

In mid-September 2018, Charter began clearing vegetative material from the landfill and installed erosion and sediment controls including sediment fence, Supersilt fence, a stabilized construction entrance, two rock check dams, and a barrier of sand super sacks within the wetland to mitigate erosion and sediment laden runoff. The existing soil on AOC 3 was shaped and graded to determine the amount of borrow material required to meet minimum slope specifications.

The subgrade was prepared to produce a uniform surface free of debris and objects that may damage the overlying geomembrane.

Sheet pile walls were installed on the perimeter of AOC 3 in locations where it was not possible to connect the side slopes directly into the surrounding~~s~~ elevations with an acceptable slope. The total sheet pile length is approximately 325 linear feet. Sheet pile was installed on the south-southeastern sides of AOC 3A, where the adjacent stream and the National Grid pole made it impossible to have a continuous acceptable slope. On AOC 3B, sheet pile was installed directly adjacent to the rail road tracks on the northern side of 3B to prevent grading and excavating near the National Grid pole. All sheets were driven with a vibratory pile hammer and torch cut to the desired elevation. Sheet pile installation was conducted by Sea and Shore, Inc.

In the wetland restoration area, the existing grade was excavated to an elevation of 111 feet above mean sea level (ASML). After waste was removed from this area, clean structural fill was imported and backfilled to a thickness of one foot and three inches. In spring 2019, one foot layer of imported organic material was added to construct the final wetland elevation to 113.25 feet AMSL. Hummocks, between one to two feet in height, were distributed non-uniformly throughout the restoration area. At this elevation the groundwater table is able to fluctuate along the sides of these hummocks, resulting in a restored wetland that is partially submerged at all times.

Wetland restoration was conducted using a phased excavation approach to minimize the generation of contact water. In this approach, waste material was excavated from the wetland in discreet cells. Each cell was immediately backfilled with clean, imported structural fill following excavation. This approach did not leave open excavations for water to reenter, limiting the need for additional dewatering and treatment of contact water.

Geosynthetic installation began at the beginning of April 2019. Geomembrane was installed after the subgrade acceptance inspection was complete. The rolls were transported using a skid steer with spreader bars from the stockpile area to the area of work. The panels were temporarily anchored with sandbags until they were seamed together with a dual hot-wedge fusion welding apparatus. The geomembrane was overlain by a geocomposite drainage layer to promote the drainage of infiltrated water in the cover soil.

In April and May 2019, cover soil was placed over the geosynthetic layers. Routine surveying was used to assess whether the grade conformed to the final RD. The placed and compacted cover soil was tested for in-place soil density at a frequency of no less than five tests per acre. The density testing confirmed that placed soils met the design requirements for compaction.

The cover soil was then overlain by a six-inch layer of topsoil and hydroseeded. In early May 2019, a wetland seed mix was then applied to the wetland restoration area. In order to establish vegetation and achieve site stabilization as quickly as possible, a seed mixture consisting of two parts *New England Wetmix* to one part *New England Erosion Control/Restoration Mix for Detention Basins and Moist Sites* was utilized. This seed mix was provided by New England Wetland Plants, Inc.

When possible, multiple phases of work were conducted simultaneously to promote an efficient project schedule. The chronology of work activities is summarized below:

10 to 18 Sept 18	Mobilization, surveying, tree clearance
18 Aug to 12 Oct 18	Debris removal, stump removal and stockpiling, installation of sedimentation and erosion controls
15 Oct to 28 Nov 2018	Shaping and preparation of subgrade
23 Oct to 02 Nov 2018	Installation of the sheet pile wall on AOC 3A and 3B
23 Oct to 30 Nov 2018	Excavation and backfill of wetland creation and restoration area
30 Nov to 14 Dec 2018	Winterization, installation of additional erosion controls
01 to 09 April 2019	Remobilization and site repair following winter shutdown.
10 to 25 April 2019	Installation of geomembrane
17 April to 25 May 2019	Installation of geocomposite drainage layer
23 April to 16 May 2019	Installation of cover soil on AOC 3A and 3B
25 April- 17 May 2019	Installation of top soil AOC 3A and 3B

30 April to 9 May 2019	Installation of organic soil in wetland
10 to 20 May 2019	Seeding of landfill caps and wetland
10 to 11 June 2019	Planting of wetlands plants
21 to 31 May 2019	Security fence installation
17 to 19 June 2019	Super sand bag removal
26 June 2019	Final erosion control removal
6 August 2019	Pre-Certification Construction Inspection

A photographical log of the RA is provided as Appendix B.

3.3 Pre-Certification Construction Inspection

The Pre-Certification Construction Inspection was conducted on 6 August 2019 for AOC 3 to confirm all items identified during prior site visits had been addressed. Attendees at the final, post-construction inspection are listed below:

- Don McElroy – USEPA
- Janet Waldron - MassDEP
- Lyndsey Colburn – ERM
- Stacey Harvey – ERM
- Sean Czarniecki - AECOM
- Rick Purdy – AECOM

4.0 CONSTRUCTION MODIFICATIONS

Constructions modifications were implemented during the RA as a consequence of varying field conditions and operations to improve the implementation and function of the overall remedy. The modifications are consistent with the intent of the approved ROD and the intent of the Final Design. All construction modifications were presented to EPA/DEP for comment and revised, if necessary. Those construction modifications are presented below and documented in the As-Built Drawing (Appendix A).

4.1 EROSION AND SEDIMENT CONTROLS

The wetland area bordering AOC 3 to the east was subject to high water levels which prevented the installation of a Super Silt Fence. Instead, a dam made of Super Sand Sacks was constructed to serve as a sediment and erosion control in this area. The dam consisted of one cubic yard super sacks filled with sand, installed along the Limit of Disturbance to match the intended Super Silt Fence line. This dam served to contain sediment from the site within the LOD and facilitate dewatering activities for excavation.

4.2 SHEET PILE ADJUSTMENTS

In the Northeast corner of AOC 3A, a subsurface obstruction was encountered during the installation of sheet pile. Further investigation revealed that the obstruction, believed to be a large boulder or stone shelf, was impractical to puncture through or remove from the subsurface. As a result, the northernmost 18 feet of sheet pile wall from stations 2+22 to 2+40 could not be installed to the target embedment depth of 15 ft below ground surface (bgs). The embedment depth in this area was 6.34 ft. bgs, which is 8.66 feet less than the required embedment depth. ERM determined that this section of sheet could support backfill to an elevation of only 113.5 ft. ASML while maintaining an acceptable factor of safety. In this area, a stone toe drainage basin was installed as an alternative to the sheet pile wall cap termination.

To accommodate this, cap limits were nominally adjusted such that the limits of cap are approximately 10 ft back from the sheet pile wall from stations 2+22 to 2+40. This adjustment was approved as test pits within this area indicated that no waste material exists outside of the adjusted cap limit. The modification to the sheet pile installation was approved by the USEPA on 7 February 2019. See Appendix C for further construction details.

4.3 SWALE EROSION CONTROLS

The Final Design called for the two drainage swales bordering the northwestern side of AOC 3A and B to be stabilized with vegetation. During construction, erosion within the swales was evident and difficult to control during the wet season. ERM determined that more robust control measures would be required to adequately stabilize the drainage swale throughout construction. Therefore, AOC 3B's swale was lined with riprap armoring along the floor and sidewalls. AOC 3A's swale was lined with riprap along the floor and erosion control mats lined the side slopes due to insignificant area for stone to be installed. The armoring of both swales will mitigate long term erosion controls.

4.4 WINTERIZATION PLAN

Additional winterization measures were taken to protect the site between December 2018 and April 2019. Straw mulch and tackifier were added to all areas at or above the 115' contour across AOC 3A and 3B. Erosion control matting was added to the transitions from the sheet pile walls to earthen slopes to limit erosion. Additional 12" coir logs were installed as part of this winterization effort; two along the wetland transition shelf on 3B, and one along the northern and western toe of slopes of 3A.

Geosynthetics were delivered to the site between 12 and 14 December 2018 and were stored on-Site through the winter. All geosynthetics were stored on plank dunnage, covered with ultraviolet-light-resistant poly sheeting, and weighed down with sandbags for storage. Inspections of the site and stored geosynthetics were conducted regularly by ERM and AECOM throughout the winter. Any erosion areas or other damage identified in inspections were promptly repaired by Charter. All repairs were reviewed by ERM and AECOM to ensure that the site maintained stable condition throughout the winter.

4.5 AOC 3B SOUTH SLOPE

Along the southeast edge of AOC 3 B, adjacent to the wetland restoration area, an elevated shelf of structural fill was created to provide space for a typical cap drainage transition. Due to the steep incline of the slope leading down from the transition shelf to the wetland, additional measures were taken to mitigate the risk of long term erosion. The outer slope was covered with geotextile and armored with six to ten-inch sized rip rap to control sheet flow from the top of cap and mitigate the erosion of structural fill into the wetland restoration area.

4.6 SUPER SAND BAG REMOVAL & WETLANDS UPDATE

Following completion of all other construction activities and establishment of wetland vegetation, the super sack dam described in Section 4.1 was reincorporated into the wetland restoration area as a row of elevated hummocks. Using a mini excavator, the sandbags were lifted and cut in-place. The plastic wrapping of the super sacks ~~were~~ removed and disposed of off-Site, and the sand within the bags was temporarily left in place as an elevated windrow bordering the wetland restoration area. Immediately following, a mini- excavator was used to reshape the sand windrow into a series of six elevated hummocks. These hummocks were then covered with organic wetland soil, seeded, and blanketed with biodegradable erosion mats secured with wooden stakes. The hummocks were then vegetated with woody wetland species consistent with the wetland mitigation plan. The final hummocks were designed to be 50 feet long with ten foot gaps in between to allow for hydraulic continuity between the existing and restored wetland. The exact dimensions of the hummocks were adjusted in the field to be non-uniform, mimicking natural land features.

To incorporate the addition of forested wetland hummocks to the restoration design, some updates were made to the layout of the wetland zones provided in the Final Design. These updates included switching the easternmost edge from a classification of palustrine emergent (PEM) to palustrine forested (PFO). The seeds, plants, and total square footage allocated to PEM and PFO remained the same, but their physical locations were adjusted. The PEM zone was relocated to the westernmost edge of the created wetland area, along the toe-of-slope of AOC 3B. The PFO zone was shifted to the eastern edge of the wetland restoration area, including the line of hummocks constructed from the reincorporated super sack dam. This change created a denser buffer along the outer boundary of newly created wetlands, assisting to mitigate the spread of *phragmites* from the existing wetland into the wetland restoration area. The original palustrine scrub-shrub (PSS) area was not changed from the original design. The PEM designated area located in the northern portion adjacent to AOC 3A also remained unchanged from the original design. The classification areas are shown on Drawing 05 in Appendix A. A list of the wetland plant species and quantities is provided in Table 1. The modification to the wetland design was approved by the USEPA on 11 June 2019. See Appendix D for further construction details.

5.0 CONSTRUCTION QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance and quality control (QA/QC) measures were implemented per the Construction Quality Assurance/Quality Control Plan approved for AOC 3. For this Site, QA/QC activities included inspections to confirm proper installation of the geosynthetic materials, piezometer decommissioning, density testing, and material thickness measurements. A description of responsibilities, procedures and results throughout construction are presented below.

5.1 POSITION RESPONSIBILITIES

Charter was responsible for the quality of construction and for compliance with the construction documents, drawings and specifications and, fulfilling applicable regulatory requirements. ERM had ultimate responsibility for the assurance of conformance with the construction drawings, specifications, and the intent of the Final Design. QA and QC personnel responsibilities and assignments throughout implementation are discussed below.

5.1.1 Construction Quality Assurance

On behalf of Pan Am, the Engineer of Record had the ultimate responsibility for the assurance of conformance with the construction drawings, specifications and SOW requirements.

5.1.2 Construction Quality Control

Charter was responsible for conducting the work in accordance with the Final Design, the applicable contract specifications and, to do so, employing best industry practices. Construction was conducted in a safe and controlled manner. Charter was responsible for providing an experienced Site Superintendent capable of ensuring that all applicable quality and contract performance responsibilities were satisfied. All QA activities for the project were coordinated between ERM and the Contractor's QC/Site Superintendent and together, they had direct control of the construction team, subcontractors, and project scheduling.

5.1.2.1 *Construction Teams*

Charter employed experienced, safety-trained construction labor. These contractors and subcontractors were trained for the functions they performed and the equipment they operated.

5.2 *QUALITY ASSURANCE AND QUALITY CONTROL ACTIVITIES*

QA/QC activities included the following:

- Engineer of Record or representative thereof review of material specifications against the Final Design prior to placement.

- Visual inspections were conducted by the Project Manager, Construction Manager, and/or CQA Manager upon delivery of geosynthetics and granular materials and prior to placement to verify material integrity and consistency with submitted material specifications.

- Visual inspections were conducted by the Engineer of Record or representative thereof to verify proper installation of the geosynthetics, material thicknesses, and geomembrane seaming.

QA/QC procedures associated with each geosynthetic component were conducted in accordance with the technical specification and are outlined in Sections 5.3 through 5.5 below.

5.2.1 *Conformance Testing*

As required by the Design Specifications, QC certification of geotextile was provided by the manufacturer. The certifications and testing covered the following:

- Material Identification
- Roll Number
- Manufacture Date
- Testing Results
    - Weight
    - Grab Tensile Strength
    - Trapezoid Tear Strength

- CBR Puncture Strength
- Apparent Opening Size (Type 1)
- Permittivity (Type 1)
- UV Resistance (Type 2)
- Puncture (Pin) Strength (Type 2)

The results of the QA/QC testing satisfactorily met the requirements in the design specifications. The material certifications and testing results are summarized in Appendix E.

5.2.2 *Delivery and Storage*

The geotextile was ordered and delivered in stages corresponding with the construction schedule.

Geomembrane and geocomposite were stored onsite through the winter in accordance with manufacturer specifications. Rolls were stacked atop plank dunnage and wrapped with opaque tarps to prevent UV damage for the duration of onsite storage. Charter and ERM checked delivery invoices and rolls for evidence of damage during shipment. Over the winter, geosynthetics were regularly inspected for damage or improper storage by ERM and AECOM as part of the site's overall winterization plan. Any damaged material was removed or repaired prior to or during installation, as appropriate. No damage was reported or observed.

5.2.3 *Deployment*

The RA Contractor's geosynthetics installer subcontractor, the RA Contractor, and ERM monitored deployment and seaming activities. This included verifying proper overlap, proper handling, and proper placement procedures

5.3 *GEOMEMBRANE LINER*

Installation requirements for the 60-mil LLDPE geomembrane were presented in Final RD, including in Specification Section 02713- Geomembrane. The physical property requirements of the 60-mil texture LLDPE were also presented in Specification 02713.

5.3.1 *Pre-Installation Material Certification and Testing*

QC certification and manufacturer's Quality Control testing of all rolls were provided. The following was the information provided on the QC certification and testing:

- Material Identification
- Roll Number
- Batch Number
- Resin Shipment Container Identification
- Manufacture Date
- Testing Results
    - Average Thickness
    - Carbon Black
    - Melt Index
    - Density
    - Tensile Properties
    - Puncture resistance
    - Tear Resistance

The test results satisfactorily met or exceeded the design specifications. Geomembrane conformance test results are presented in Appendix F.

5.3.2 *Delivery and Storage*

The LLDPE geomembrane rolls were stored in accordance with manufacturer recommendations. The RA Contractor checked delivery invoices and condition of material upon arrival. Damaged geomembrane rolls were marked and portions of the damaged rolls were removed prior to installation or repaired after installation, if necessary.

5.3.3 *Geomembrane Deployment*

Geomembrane was installed immediately after subgrade acceptance inspection and only on subgrade that met the criteria of Section 02713 as verified by joint inspection by the EPA oversight contractor representative, RA Contractor, and ERM CQA personnel. Subgrade acceptance forms are provided in Appendix F.

A skid steer equipped with spreader bars was used to transport the rolls from the stockpile area to the area of work and unroll them for final placement. Smaller panel placements and adjustments were achieved by hand-pulling using hand clamps fastened to the geomembrane. The geomembrane panels were assigned an identification number, which was based upon the sequential order in which the panels were deployed. The panel layout is illustrated on the record drawings in Appendix F.

The geomembrane panels were temporarily anchored with sandbags until they were seamed together. Damaged or blemished areas of the geomembrane were repaired in accordance with specifications. The RA Contractor, their geosynthetics installation subcontractor, and ERM visually monitored the geomembrane panels during deployment for alignment, sheet surface quality, overlap with adjacent panels, identification (roll number and panel number), panel length, and underlying surface quality. QA and QC records were kept during deployment and are presented in Appendix F.

5.4. SEAMING

5.4.1 Trial Seams

Trial seams were made for each fusion/extrusion welding machines and operator at the start of each day and after each work break/stoppage that resulted in an equipment shutdown. Trial seams were made with pieces of geomembrane welded together under the same ambient air conditions as the field seaming to be performed. Trial seam testing established temperature and speed settings on the welding units conducive to formation of acceptable seams. Six sample coupons were cut from each trial seam. Three of the six coupons were tested in the peel mode of the inner and outer weld and three coupons were tested in the shear mode with a calibrated tensiometer. This tensiometer was used to verify Film Tear Bond as well as shear and peel strength requirements of 100 and 70 pounds per inch for fusion welding, and 100 and 50 pounds per inch for extrusion welding, respectively. Trial seam testing documentation is provided in Appendix F.

5.4.2 Field Seams

The majority of geomembrane field seams were made using a dual hot-wedge fusion welding apparatus. Repairs and short seam segments were made using an extrusion welding apparatus. The seaming operations were observed and documented by the RA Contractor's geosynthetics installation subcontractor, the RA Contractor, and ERM. The entire length of all seams, patches, or other repairs were also measured, observed, and documented.

Monitoring of the seaming process for quality assurance purposes consisted of periodic observations to ensure that the proper procedures were being followed, including seam preparation, seaming apparatus temperatures, and completed seam quality. Seaming imperfections were marked and subsequently repaired in substantial conformance with Design Specification Section 02713-J Defects and Repairs.

A tracking process was used during the field seaming. Each seam was identified with a unique seam number, which consisted of the panel numbers joined by the seam. Other recorded seam data included the date and time, length, name of welder, and welding device number. This information is presented in Appendix F.

5.4.3 Nondestructive Testing

All nondestructive seam continuity testing was performed by the RA Contractor's geosynthetics installer subcontractor and observed by the RA Contractor and ERM. Two types of nondestructive testing were performed:

- Air pressure testing
- Vacuum box testing

The fusion seams were nondestructively tested by air pressure testing the channel formed between the two tracks formed during seaming by the dual hot-wedge fusion welding apparatus. The end of the seam to be pressure tested was sealed and a hollow needle with an attached pressure gauge was inserted in one end of the seam. The seam channel was filled with air using an electric air compressor to reach a pressure between 25 and 30 psi. The pressurized channel was monitored for a period of five minutes. For the seam to meet specifications, the seam was permitted to lose no more than 4 psi during a 5-minute period. Following the 5-minute period, the seam end opposite to the needle was cut, and the pressure drop was observed. This method was performed to verify that the entire seam length was tested and that the air channel was not blocked by debris or sealed by overheating during seaming. If a section of seam did not pass the air test, then the leak or blockage was located and repaired. The seam was then retested on both sides of the defection or the seam would be repaired by leistering and extrusion welding a patch of geomembrane across the failed seam length and subsequently nondestructively (vacuum) tested. A summary of the QA/QC test results for the seams of geomembrane air pressure testing is presented in Appendix F.

Extrusion welded seams and repairs were nondestructively tested using a vacuum box. A vacuum box is a rigid wall box with a clear Plexiglas® (or similar) top and a neoprene gasket around the bottom of the box (to serve as a seal between the box and the geomembrane). Vacuum box testing consisted of applying a soapy water solution to the seam and placing the vacuum box over the seam. A vacuum of 5 psi was drawn on the chamber for approximately 30 seconds to observe the weld area. Any area where soap bubbles appeared generally indicated a seam discontinuity or leak. These areas were marked, repaired, and retested in accordance with the technical specification. QA/QC nondestructive test results for extrusion welds are included in Appendix F.

5.5 DESTRUCTIVE TESTING

5.5.1 Sampling and Test Procedures

Geomembrane destructive seam test samples were obtained on an average of one for every 500 linear feet of seam of each welding apparatus, which was in accordance with the technical specifications. The test locations were selected by ERM based either on completion of approximately 500 feet of welding or on individual weld observations (e.g., biased to areas of variable welding). After marking the sample location, the RA Contractor's geosynthetics installer cut the sample, which was typically 12 inches wide by 44 inches long with the seam centered lengthwise, from the installed geomembrane. The geomembrane destructive sample was cut typically into three sections and distributed as follows:

- One 12-inch by 12-inch section to ERM for laboratory testing;
- One 12-inch by 12-inch section to the RA Contractor for laboratory testing; and
- One 12-inch by 12-inch section for archive storage.

Destructive samples were field tested with a calibrated tensiometer prior to being sent for laboratory testing. Four coupons were cut from each destructive sample. Two coupons were tested for peel strength for the inner and outer seam on fusion welds and two were tested for shear strength. Upon acceptance of the field testing, destructive samples were shipped to the offsite QA and QC laboratories for testing. Ten coupons were sent from each destructive sample. Five coupons were sent to test peel strength for the inner and outer seam on fusion welds and five were tested for shear strength. Acceptance criteria for the destructive samples were 70 pounds per inch for peel and 100 pounds per inch for shear for fusion welding, and 100 and 50 pounds per inch for extrusion welding, respectively. The locations of the geomembrane destructive tests and a summary of the destructive samples test results can be found in Appendix F.

5.5.2 *Tracking of Failed Destructive Samples*

There were no failed destructive tests. A summary of the field and laboratory test results can be found in Appendix F.

5.5.3 *Repairs*

All destructive sample and air pressure testing locations were extrusion welded and nondestructively tested using a vacuum box. The RA Contractor's geosynthetics installer subcontractor, the RA Contractor, and ERM observed repair activities and documented that the identified defects were repaired and nondestructively tested in accordance with the technical specifications. QA/QC nondestructive test results and the locations of the repairs for extrusion welds are included in Appendix F.

5.5.4 *Interface Shear Testing*

Interface shear testing was performed to verify the stability of the cap system interfaces, particularly on the 3 Horizontal: 1 Vertical slope areas. Shear interface friction angle testing was performed on the following cap components:

- geomembrane- existing subgrade interface;
- geomembrane- subgrade fill interface;
- geotextile-geomembrane interface;
- geomembrane-geocomposite interface;
- geocomposite-cover soil interface; and
- cover soil-cover soil interface.

Testing performed met or exceeded the material property requirements specified in the design. Testing data are provided in Appendix F.

5.6 *GEOCOMPOSITE DRAINAGE LAYER*

The geocomposite drainage layer was installed to help promote drainage of water that infiltrates through the cover soil. The geocomposite is manufactured from a geonet and lamination of a nonwoven geotextile on the top and bottom of the geonet. The fabric permits water to permeate, yet prevents the adjacent soil from washing through the core. Installation and physical property requirements for the geocomposite were presented in Design Specification Section 02712 Geocomposite.

5.6.1 *Conformance Testing*

As required by the Design Specifications, QC certification of geocomposite was provided by the manufacturer. Periodic QA/QC laboratory testing was also performed to verify that the material met the material property requirements in the design. The certifications and testing covered the following:

- Material Identification
- Roll Number
- Batch Number
- Resin Shipment Container Identification
- Manufacture Date
- Testing Results
  - Average Thickness
  - Carbon Black
  - Melt Index
  - Density
  - Tensile Properties
  - Weight
  - Transmissivity
  - Ply Adhesion
  - Apparent Opening Size
  - Permittivity
  - UV Resistance

The results of the QA/QC testing satisfactorily met the requirements in the design specifications. The material certifications and testing results are summarized in Appendix G.

5.6.2 *Delivery and Storage*

The geocomposite was ordered and delivered in stages corresponding with the construction schedule.

Storage was in accordance with manufacturer specifications. The RA Contractor field personnel checked delivery invoices and rolls for evidence of damage during shipment. Any damaged material was removed or repaired prior to or during installation. No substantial damage was reported or observed.

5.6.3 *Deployment*

Geocomposite was installed over the completed sections of geomembrane following geomembrane acceptance and testing. The geocomposite rolls were transported to the deployment location and unrolled using a skid steer and spreader bar. Final panel placement was achieved by hand adjusting the panels. Sandbags were utilized to temporarily anchor the material in place until seaming. The RA Contractor's geosynthetics installer subcontractor, the RA Contractor, and ERM monitored the deployment of the geocomposite to ensure proper overlap, to verify proper handling and placement procedures, and to verify protection of the installed geomembrane.

The geonet portion of the geocomposite was seamed by the placement of plastic ties. The ties were of a contrasting color to aid in inspection of the seams. Ties were placed a maximum of five feet apart on adjacent seams and two rows of ties two feet apart on roll ends. The geosynthetics installer subcontractor, the RA Contractor, and ERM monitored the placement and spacing of the ties.

The geotextile portion of the geocomposite was overlapped and sewn the full length of the seam by the contractor using the specified material and procedures in Design Specification Section 02712-3.02. The seaming activities were monitored closely to ensure seam quality and completeness. Any portion of the seam that was not correctly stitched together was marked for repair and corrected. Any portion of the seam or geotextile that was damaged or in need of a patch was repaired utilizing a geotextile patch of the same type that extended a minimum of 12 inches larger in all directions of the area that was to be repaired. A final inspection of all areas was performed by geosynthetics installer subcontractor, the RA Contractor, and ERM personnel prior to acceptance.

Upon completion and acceptance of the geocomposite drainage layer portion of the cap system, the geocomposite was covered with soil in accordance with the specifications outlined in Design Specification Section 02200.

5.7 *PIEZOMETER DECOMMISIONING*

Groundwater piezometers (PZ-104A, PZ-104B, PZ-105B, and PZ-106B) were decommissioned by Charter on 22 October 2018 in accordance with MassDEP regulations. The piezometers were abandoned in place through filling with bentonite and cutting the PVC at the surface. None of the abandoned wells were part of the long term groundwater monitoring program. Piezometer decommissioning reports are included as Appendix H.

5.8 MATERIAL THICKNESS & GRADES

Grade stakes, field measurements, and routine surveying were used to assess whether the grades and layer thicknesses conformed to the Final RD. The subbase and final condition surveys can be found in Appendix A.

5.9 DENSITY TESTING

Compacted cover soil was tested for in-place soil density at a frequency of no less than five tests per acre (thirty-two total tests). The density testing confirmed that placed soils met the design requirements for compaction (Table 2).

6.0 INSTITUTIONAL CONTROLS

Institutional controls will be applied to AOC 3 in accordance with the Institutional Control Plan, which describes non-engineered administrative and legal measures to reduce the potential for human exposure to contamination and to protect the remedial remedy.

7.0 REGULATORY COMPLIANCE ASSESSMENT

7.1 RECORD OF DECISION COMPLIANCE

As outlined in the RD, the RA was intended to "…mitigate, restore and/or prevent existing and future potential threats to human health and the environment." The ROD specified three remedial action objectives specific to AOC 3:

- Limit the migration of contaminants in soil to groundwater;
- Prevent exposure to lead soil concentrations greater than 1,736 mg/kg; and
- Protect short-tailed shrews and other small mammals from exposure to copper and lead in soils.

The components of the remedy were implemented to meet those objectives and inspections, maintenance, institutional controls and monitoring will ensure long term effectiveness.

7.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS COMPLIANCE

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires remedial actions at National Priorities List (NPL) sites to meet the ARARs under federal or state environmental laws and regulations. For on-site work, CERCLA actions do not require a permit; however, substantive requirements of the ARARs need to be met.

Section M in Part II and Table L-10 of the ROD presents the federal and state ARARs that may apply to work that would be conducted at AOC 3. The selected remedies presented in the ROD were developed to comply with the substantive requirements of these ARARs. This section summarizes the primary chemical-, location-, and action-specific ARARs that directly apply to the work conducted at AOC 3.

Chemical-Specific ARARs

Chemical-specific ARARs are health- or risk-based concentration limits or ranges that establish acceptable limits or concentrations of a contaminant, or a basis for calculating such limits. There were no applicable or relevant and appropriate chemical-specific ARARs for AOC 3. However, the following guidance was characterized as "to be considered":

- Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil- EPA guidance for evaluating the risks posed by lead in soil;

- Cancer Slope Factors - Guidance used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in Site media; and

- Reference Dose - Guidance used to characterize human health risks due to non-carcinogens in Site media.

Location-Specific ARARs

Location-specific ARARs establish restrictions on the types of remedial activities that can be performed based on specific location, such as wetlands or floodplains. AOC 3 is located within state and local jurisdictional areas. The federal, state, and local laws and regulations that affect work conducted in AOC 3 include the following:

- Wetland ARARs – The remedial action was designed and implemented to minimize impacts to wetlands. In accordance with state and federal regulations, temporary and permanently disturbed wetlands were restored and mitigated as needed. Best Management Practices were employed to disturb the smallest area required to effectively cap the exposed areas of asbestos at AOC 6.

    - Clean Water Act (33 USC. §1251 et seq.); Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material (40 CFR Part 230, 231 and 33 CFR Parts 320-323) – The project was located within the 100-foot Buffer Zone of a wetland. Sedimentation and erosion control measures were installed to prevent discharges of fill material and protect aquatic ecosystems.

- Wetlands Protection Act (Mass. Gen. Laws ch. 131, §40), Wetlands Protection Regulations (310 CMR §10.00) – The project was located within the 100-foot Buffer Zone of a wetland. Measures were taken to minimize adverse impacts to nearby wetland resource areas during construction and the contact water treatment system was designed to meet the MassDEP Standards, as applicable.

- Executive Order 11990 "Protection of Wetlands" (40 CFR Part 6, Appendix A) - No new construction is proposed within wetlands and the remedy was intended to restore wetland and improve conditions proximate to existing wetlands.

- Fish & Wildlife ARARs – The activities associated with AOC 3 did not involve impacts to any federally listed threatened or endangered species based on the U.S. Fish and Wildlife Service list of species for Middlesex County. Therefore, consultation with the U.S. Fish and Wildlife Service was not required.

  - Fish and Wildlife Coordination Act (16 USC 16 USC §661 et seq.), Fish and Wildlife Protection (40 CFR §6.302(g)

Action-Specific ARARs

Action-specific ARARs establish controls or restrictions on the design, implementation or performance of a remedy. The following federal and state laws and regulations affect the actions to be conducted at AOC 3.

- Surface water pollution ARARs – Remedial activities were conducted to minimize impacts of site-related contaminants to surface water.

  - Clean Water Act Ambient Water Quality Criteria (40 CFR 120); and

  - Massachusetts Clean Waters Act (Mass. Gen. Laws ch. 21 §§26-53); Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredged Materials in Water of the United States within the Commonwealth (314 CMR §9.00).

- Hazardous Waste Management ARARs – hazardous waste generated during the course of remedial activities was handled and managed in accordance with the requirements of the federal and state hazardous waste regulations.

- RCRA Subtitle C – Hazardous Waste Identification and Listing Regulations; Generator and Handler Requirements (40 CFR Parts 260-262 and 264); and

- Management Standards for all Hazardous Waste Facilities (310 CMR 30.500), Waste Analysis (310 CMR 30.513); Management Standards (310 CMR 510).

- Solid Waste Capping ARARs – The remedial actions ~~met~~ the closure/post-closure standards through capping, monitoring and institutional controls. The cap construction addressed potential risks to human health and the environment and prevents migration of contaminants to surface water and groundwater.

    - Massachusetts Solid Waste Management Regulations (310 CMR 19.00); and

- Massachusetts Department of the Environment (MassDEP) Landfill Technical Guidance Manual; Massachusetts Solid Waste Management Regulations (310 CMR 19.00) – Wastes generated during the course of the remedial activities that were determined to be non-hazardous were handled and managed in accordance with the requirements of state solid waste regulations.

- Air Pollution ARARs - Actions were taken to control the generation of dust during excavation and capping activities, as needed.

    - Massachusetts Air Pollution Control Regulations (310 CMR 7.09).

8.0 FUTURE REQUIREMENTS

O&M procedures are described in detail in *Appendix H: Operations and Maintenance Plan AOCs 1, 2, 3, and 6* of the *Final (100%) Remedial Design for AOCs 1, 2 and 3* dated September 24, 2012. The O&M plan for AOC 3 addresses the following:

- Post-closure inspection of cap construction areas, storm water controls, fencing, monitoring wells, sheet pile, drainage features, and perimeter security fence;
- Mowing on an as-needed basis and removal of any identified woody plants on and in the immediate vicinity of the cap;
- Documentation and reporting; and
- Routine maintenance and repairs.

On-going inspections have been, and will continue to be, performed including the cover system, fencing, sheet pile, and drainage controls. The inspections will occur quarterly for the first two years and semi-annually thereafter for a minimum of thirty years. The frequency of inspections may be modified as appropriate based on site conditions (e.g. frequency of vandalism).

The long term monitoring procedure for the restored wetland area is detailed in *Appendix I: Wetland Restoration and Creation Plan* of the *Final (100%) Remedial Design for AOCs 1, 2 and 3* dated September 24, 2012. The restored wetland area will be monitored for the first three full growing seasons following completion, and then again during the fifth, seventh, and tenth growing seasons. During inspection and reporting years, the area will be inspected at least two times during the growing season (late spring and late summer). The monitoring plan includes the following activities:

- Late spring inspections of restored wetland area to observe and document potential erosion or soil disturbances, evidence of hydrology, wildlife browsing on planted species, invasive species, and conditions that necessitate corrective action;
- Late summer inspections of restored wetland area including vegetation coverage analysis, vegetation richness analysis, tree height measurement, survivability assessment, photographic documentation,

identification of invasive species, and identification of conditions that necessitate corrective action. Late summer inspections on the third and fifth year of monitoring including evaluation of soils within the created wetland and documentation of the development of hydric soil characteristics; and

- Establishment an~~d~~ annual evaluation of four long-term wetland sampling plots to quantitatively assess wetland vegetation.